

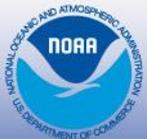
NATIONAL GEODETIC SURVEY

CORS USERS FORUM

Towards Real-Time Positioning

Richard Snay
NOAA's National Geodetic Survey

CGSIC Meeting
Long Beach, CA
September 13, 2005



National Oceanic and Atmospheric Administration

Agenda

- 1:30 CORS/OPUS: Status & Overview
Richard Snay, NOAA's National Geodetic Survey
- 1:45 EarthScope's Plate Boundary Observatory
Greg Anderson, UNAVCO, Inc.
- 2:05 Post-Processing Versus Real-Time GNSS
Georg Weber, German Federal Agency for Cartography
and Geodesy
- 2:25 The International GNSS Service—Progress Towards Real-Time
Mark Caissy, Natural Resources Canada
- 2:45 CORS/OPUS: Future Prospects
Charles Schwarz, NOAA's National Geodetic Survey
- 3:00 Question & Answer Session
- 3:20 Break
- 3:35 Interactive Sessions within Small Discussion Groups
- 5:00 End



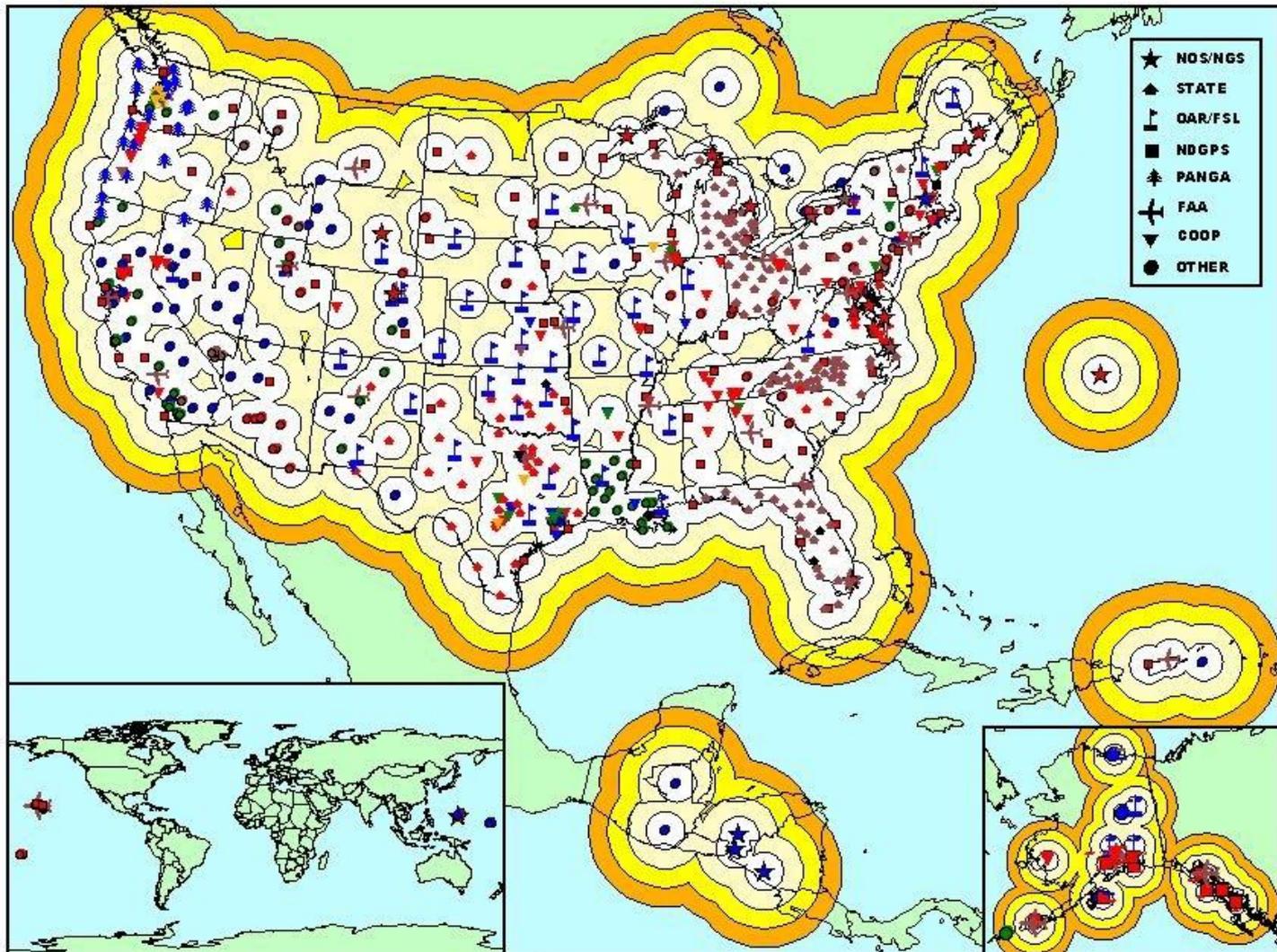
Interactive Sessions (3:35 – 5:00 pm)

- A. Towards real-time CORS products and services
Charles Schwarz, Miranda Chin, and Bruce Sailer
- B. OPUS, UFCORS, and other CORS utilities
Tom Soler, Dale Pursell, and Marti Ikehara
- C. Guidelines for establishing CORS sites
Giovanni Sella, Don Haw, and Julie Prusky
- D. Ionospheric & tropospheric models
Tim Fuller-Rowell and Dru Smith



Continuously Operating Reference Stations

CORS Coverage (100, 200, 300, and 400 km radius) January 2005



Symbol color denotes sampling rates: (1 second) (5 seconds) (10 seconds) (15 seconds) (30 seconds)

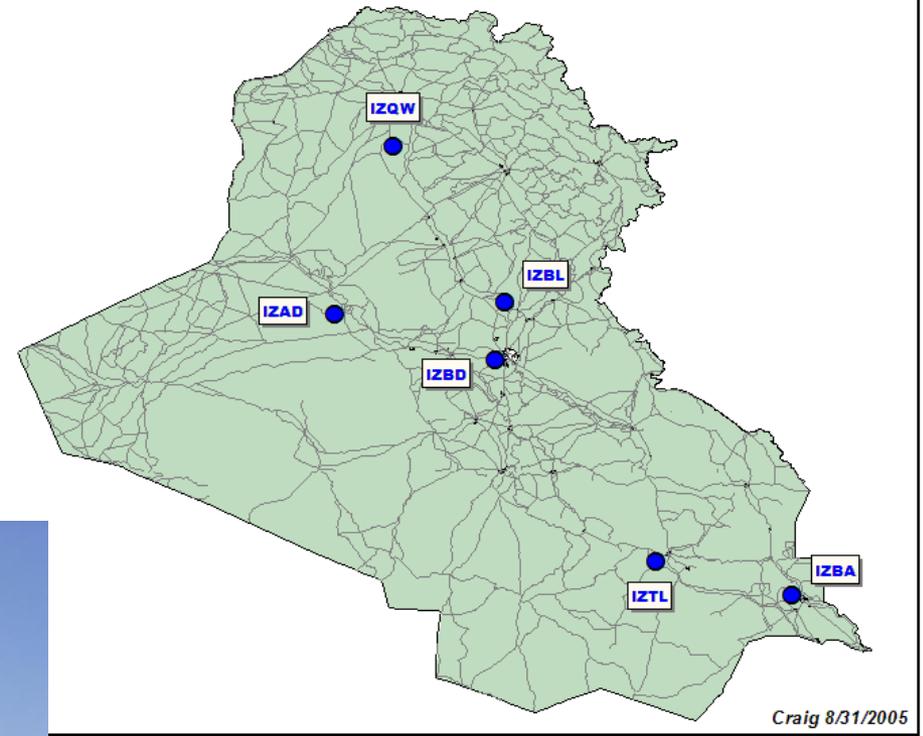
CORS OVERVIEW

- National CORS Network contains 667 sites
- Cooperative CORS Network contains 140 sites
- California CORS Network contains 350+ sites
- Combined CORS Network growing at rate of 15 sites per month
- More than 155 organizations participate in the CORS program
- Provides code range (C/A, P1, P2)
 - and carrier phase observations (L1, L2)

CORS APPLICATIONS

- Postmission Static Positioning (cm-level accuracy with a few hours of data, dm-level accuracy with one minute of data)
- Postmission Kinematic Positioning (dm-level accuracy for an aircraft, boat, or land vehicle)
- Geophysics / Crustal Motion
- Meteorology / Water Vapor in Atmosphere
- Space Weather / Free Electrons in Ionosphere

CORS NETWORK NOW CONTAINS 6 IRAQI SITES



*Established by
U.S. Army*

CORS ACCOMPLISHMENTS

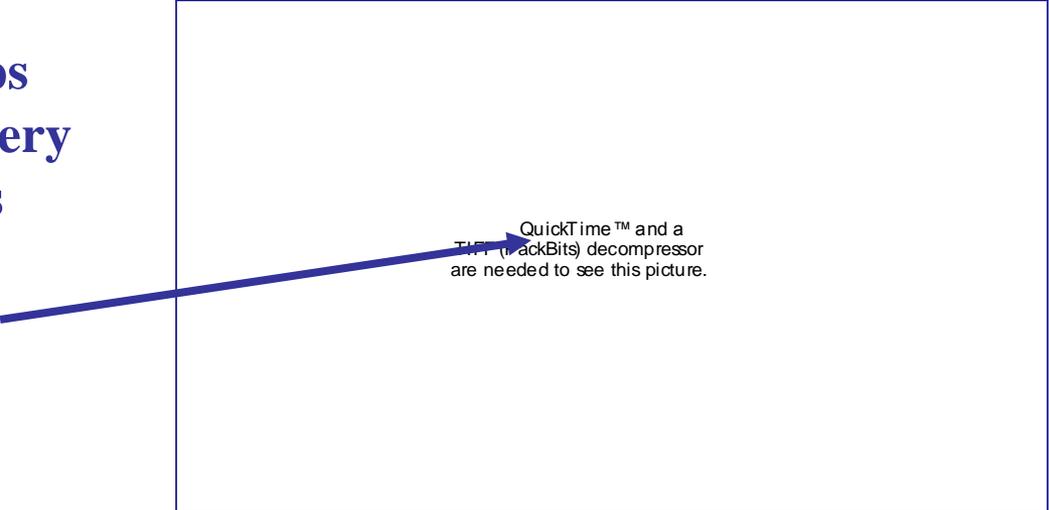
in FISCAL YEAR 2005

- Combined CORS network grew by more than 240 sites. (Thanks mainly to EarthScope's Plate Boundary Observatory and to RTK networks being established by state and local governments.)
- Accuracy of NGS-produced orbits improved by 37.5% (4 cm → 2.5 cm).
- NOAA now using CORS data to nowcast Total Electron Content (TEC) over CONUS every 15 minutes.
- NOAA now using CORS data operationally to nowcast precipitable water vapor over CONUS every hour.
- NOAA now validates positional coordinates of Cooperative CORS sites daily (previously it was done monthly).
- The Online Positioning User Service (OPUS) processed 150,000 GPS data sets.

US-TEC Product

- * **Since November 2004, an experimental product characterizing the ionospheric total electron content (TEC) over CONUS has been running in real-time at NOAA's Space Environment Center (SEC)**
- **Uses a Kalman filter and ingests ground-based GPS data to produce 2-D maps of TEC**
- **Product evolved from a collaboration between NOAA's National Geodetic Survey (NGS) and SEC**

Real-time ionospheric maps of total electron content every 15 minutes. Currently uses about 60 real-time GPS stations from the CORS network



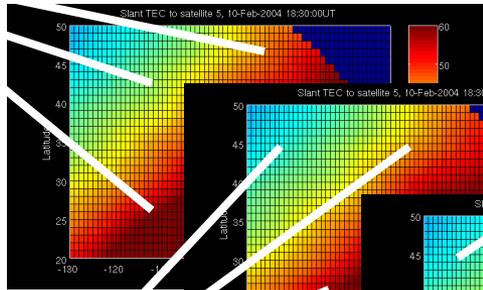
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Slant-Path TEC Maps

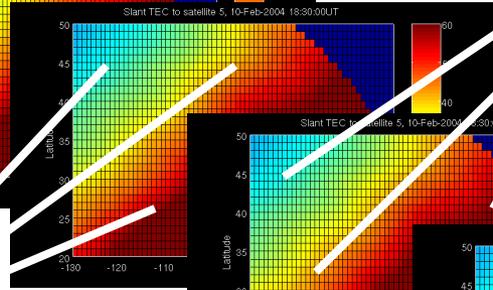
- The work horse of the product consists of 2-D maps of slant path TEC over the CONUS for each GPS satellite in view, updated every 15 minutes
- estimates of the group delay or phase advance for the GPS signals anywhere in the CONUS



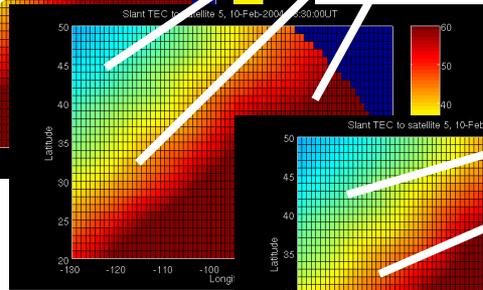
Sat. 1



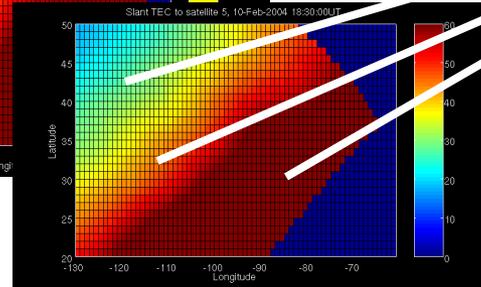
Sat. 14



Sat. 5



Sat. 29



...etc

US-TEC Applications

- Ionospheric correction for single frequency GPS and NDGPS positioning
- Dual-frequency integer ambiguity resolution for rapid centimeter accuracy positioning

Plans for US-TEC

- **Product approved for transition to full operations in Spring 2006**
- **Parallel data stream from CORS-East and CORS-West will increase reliability**
- **Increase number of real-time stations over CONUS by including WAAS stations, plus stations operated by NOAA's Forecast Systems Lab**
- **Include Canadian-sponsored IGS stations to improve poleward coverage**
- **Increase cadence to 5 minutes**
- **Provide short-term forecast (10 to 30 minutes) to bring up to, or just beyond, real-time**

ON THE CORS HORIZON

Within the next 3 months

- * 15 Mexican sites will join the CORS network.
- * OPUS-DB (database) will allow users to archive their results in the National Geodetic Survey's database.
- * NOAA will release new guidelines for establishing CORS sites and managing CORS information.

Mexican National Active Geodetic Network

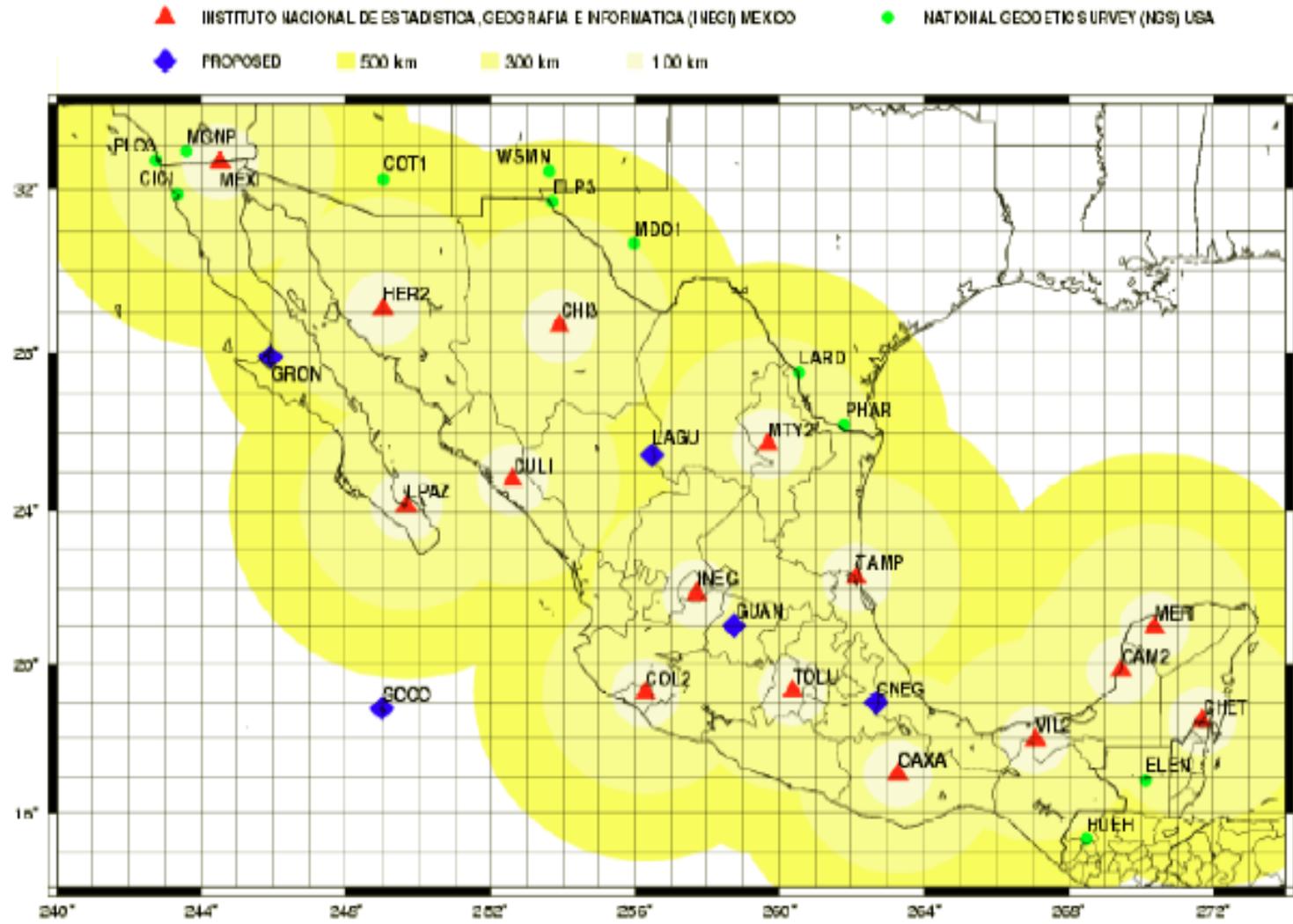
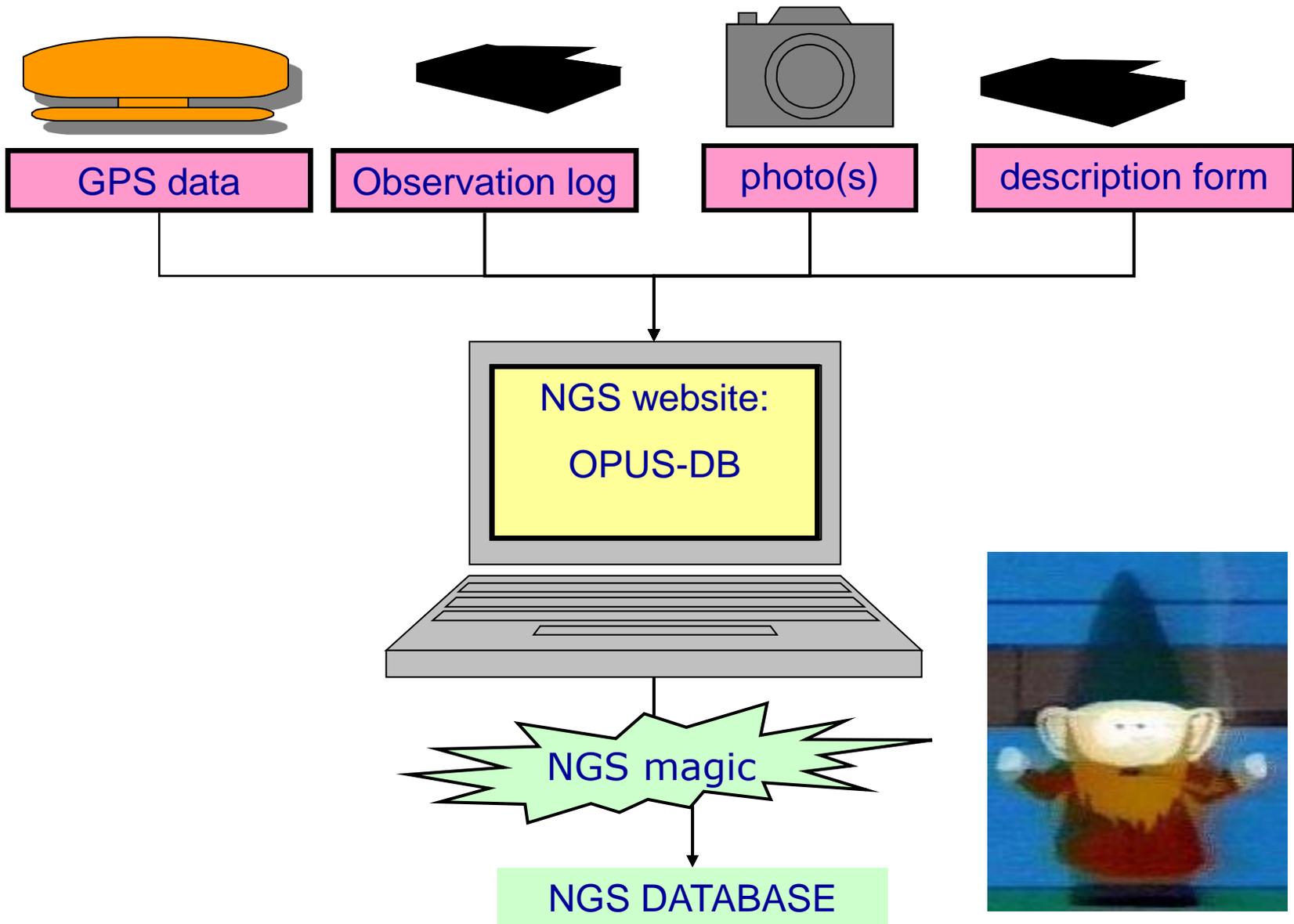


Figure 1. National Active Geodetic Network RGNA

OPUS-DB OBSERVATION DATA STREAM



NEW CORS GUIDELINES

GOALS:

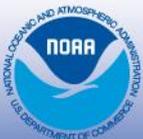
- Improve quality of CORS data
- Focus attention on CORS meta-data requirements

Selected Items:

- * Team established to evaluate new sites more rigorously before including them into the CORS network
- * Encourage more stable sites
- * Avoid multipath-prone sites
- * Radomes not recommended except ...
- * Track all satellites regardless of their health status
- * Track satellites to lower elevation angles
- * Provide suite of photos for each site

ONGOING CORS RESEARCH

- * Exploring the use of NTRIP to stream GPS data from selected CORS via the Internet.
- * Developing OPUS-RS (rapid static) that will enable users to obtain positional coordinates with cm-level accuracy using only 15 minutes of data



PROPOSED POLICY FOR STREAMING GPS DATA VIA THE INTERNET

- NOAA's National Geodetic Survey (NGS) is exploring the possibility of streaming GPS data (not correctors) from selected Continuously Operating Reference Stations (CORS) via the Internet.
- These data will be publicly available and free of direct user fees.
- NGS is openly distributing these data to enable other organizations to provide location based services relative to the National Spatial Reference System.
- Users may also apply these GPS data to
 - * monitor the distribution of free electrons in the atmosphere,
 - * monitor the distribution of precipitable water vapor in the atmosphere, and
 - * record the passage of seismic waves.
- While these GPS data may be applied to track the path of a moving platform--such as an aircraft, water vessel, or land vehicle--these data will not possess sufficient "integrity" to support a robust navigation service.